than the next environs of Winnipeg. For this fact the physical causes are:

(1) High-temperature constancy between I–II and III–IV in Manitoba.

(2) Prevailing northwest winds in Ontario and New England in the early spring.

(3) The thermic effect of the great fresh-water lakes, therefore, we will consider the relations in a cold winter in Manitoba.

Manitoba I–II severe; III–IV cool also Ontario, Michigan, etc.; I–II generally severe also; III–IV prevailing northwest winds Manitoba-Atlantic bringing cool temperature from the interior; temperature negatively influenced by the over-blown ice masses of the lakes.

SUMMARY

The two generally severest months in Manitoba (January and February) are of enormous influence on the immediately following March-April eastward; the very close connection enables one to give in future two reasonable forecasts for these months for the whole area of the Great Lakes region and New England. The correlation $r = \leqq 0.60$ covers an area about twice the size of Germany.

EDITOR'S NOTE.—In a recent communication Mr. Groissmayr indicates that he has discovered a relation between spring temperature at Dawson, Alaska, and the immediately following summer temperature in the middle Mississippi Valley. He expects to favor readers of the REVIEW with a note on the subject in a few months.—*A. J. H.*

WEATHER ABNORMALITIES IN THE UNITED STATES (SIXTH NOTE): TEMPERATURE DISTRIBUTION

By ALFRED J. HENRY

[Weather Bureau, Washington, June, 1930]

The monthly mean temperature distribution with respect to departures from the normal is shown on Chart III of this REVIEW. The shaded areas represent departures above the normal and the unshaded areas represent departures below the normal.

Anyone who has observed Chart III month by month must have noticed that normal temperature seldom occurs in any month except along a more or less arbitrary line drawn on the chart to separate districts having negative departures from those of opposite sign. The monthly mean temperatures along the zero line or line of no departure from the normal is approximately normal.

It may have been observed also that months when the mean temperature anomaly is in the same sense over the whole country are of rather infrequent occurrence. The most frequent distribution is a mixed one, some areas having a positive departure and others a negative. The purpose of this paper is to explain so far as is possible the occurrence of sharply contrasted anomalies.

The Rocky Mountains as a climatic divide.—The Rocky Mountains at times act as a climatic divide, especially as to temperature, and the reason is not far to seek. It has been established that the flow of polar air equatorward takes place along and near to the surface of the ground, say up to 3,000 to 4,000 feet. Since the summits of the Rocky Mountains are generally at a greater altitude than the above figures and since the cold air generally flows equatorward along the east slope of the mountains the range serves as a barrier to prevent the overflow of cold air to the areas west of the mountains. There are other factors which in connection with the barrier effect operate to keep temperature west of the mountains at a higher level on occasions than air to the east of the mountains. These factors are in the main, the place of origin and direction of movement of cyclonic systems and areas of high pressure (anticyclones); these in turn are controlled by the pressure distribution over large areas remote from the west coast of the North American continent. The lack of adequate meteorological data from the vast water surface between the Asiatic continent and North America makes it difficult to place ones finger upon the controlling cause or causes of origin and any tentative explanation that may be offered must be largely speculative. It is only within very recent years that meteorologists have been able to gain any knowledge of the pressure distribution over the North Pacific.

Consider first the condition *warm east, cold west of the Rockies:* This condition has been found in 6 winter months out of a total of 111 in the last 37 winters; it is therefore a phenomenon of rather infrequent occurrence.

In the best-developed type, that of December, 1928, for example, the current pressure distribution for the month was considerably below normal in the Aleutian and Gulf of Alaska areas and above the normal over the middle part of the North Pacific from approximately the longitude of Midway Island, 177° west longitude, to the western part of the United States. That pressure distribution leads to the inference that cyclonic systems would, as they did, develop and move across the North American continent in relatively high latitudes; the inference is also permitted that by reason of high pressure over western United States, secondary cyclones would develop over the southern plateau and this inference also was realized. The development of cyclonic storms over that region tends to create a flow of cold air southward over the territory west of the Rockies. Finally, as it happened, but we do not know the reason why, there were no strong anticyclones in that month with their associated flow of cold air to the southward which takes place in a normal winter month, but rather nearly all of the anticyclones of the month developed near the Canadian border but within the United States and naturally they did not bring very much reduction in the temperature.

Most of the six cases studied had the common feature of low pressure in the Aleutians and high pressure over western United States as well as over the Pacific between Honolulu and the California coast.

The reverse condition, viz, *warm west, cold east of the Rockies*, will follow when many cyclonic systems pass inland from the Pacific over British Columbia and move thence east or southeast across the Rockies. Cyclones so moving cause a flow of warm oceanic air across the Pacific Coast States and the plateau region. If, now, a number of high-pressure areas (anticyclones) advance south-southeastward from Canada, the point of entry into the United States being east of the Rocky Mountains, and if the movement is continued for several days as in December, 1917, surface temperatures east of the mountains will suffer a pronounced lowering according to the magnitude of the flow of polar air.

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Another moderately frequent temperature distribution in winter months is that in which the line of zero change from the normal runs in a north-south direction, not along the main Rocky Mountains but at some distance eastward. These cases have not been studied in detail but it is believed they differ in no essential from those already discussed.

In addition to the cases where the dividing line between positive and negative departures runs in a north/south direction or at some angle oblique thereto there are cases not very numerous where the dividing line has an east/west direction. In these, as well as in all cases, the use of a time unit other than the calendar month would doubtless yield results that would differ materially from those now available and this would be the case more especially as regards the effect of cold polar air flowing equatorward, since that flow if begun near the close of the month would not have had sufficient time to effect the monthly means of temperature the entire distance between the Canadian border and the Gulf of Mexico. Rather frequently the area of negative departure is confined to the upper Missouri Valley, a favorable point of entry of cold waves from Canada. As might be expected, the distance that frigid temperatures penetrate the United States from the north will depend upon the duration of the polar currents, an extreme case is that of January, 1916, when the temperature departure in Montana was 25° F. below normal and in Florida 9° above.

The distribution *cold north, warm south*, or the contrary, is not frequently experienced. Notable cases occurred in February, 1902, and 1905. In 1902, the monthly mean pressure distribution—the chief control of the temperature—took the form of a southeast/northwest directed ridge of high pressure that stretched from Tennessee to and beyond the Canadian border. This ridge served as a wind divide, places on the east slope having cold northwest winds and places on its west side having southerly to westerly winds. The ridge also served as a barrier over which cyclonic systems from the Pacific could not surmount; these storms therefore moved in a southeasterly direction to the southern plains States and thence east and northeast along the Atlantic coast, a movement which greatly augmented the flow of cold air from higher latitudes and as a consequence the temperature in the Gulf and Southeastern States was 4, 6, 8, and 10 degrees below the normal, while in Wyoming and adjacent States the temperature was about the same amount above the normal thus creating a very abnormal temperature distribution. In February, 1905, the continental ridge of high pressure [1] was exceptionally developed with a single crest that was centered over the lower Missouri Valley and the middle plains States where average pressure was 30.30 inches, close to a quarter inch above the normal. This exceptional development caused the first half of the month to be continuously cold, especially in the south where subnormal temperatures were persistent, the monthly abnormality being as much as 10° below the normal in the Gulf States tapering to about normal temperatures along the Canadian border and thence westward to the Pacific.

Finally there remain to be discussed those months in which the temperature anomaly was uniformly in the same sense in all parts of the country, in other words it was uniformly cold or warm in all parts of the country, although not by the same degree.

In the last 20 years (1909–1928) there have been 36 months during which at least 90 per cent of the total area of the United States had positive temperature departures and in 12 of these months 100 per cent of the total area was uniformly positive. On the other hand but 12 months in the same 20 years had negative departures over at least 90 per cent of the total area and but a single one of the 12, May, 1917, had 100 per cent of area with negative temperature departures.

These facts show unmistakably that the last two decades have been warm. If we go back two more decades, 1889–1908, the count stands 23 warm months as against but 17 cold, or a total in the 40 years, 1889–1928, of 59 warm and 29 cold.

The apparent cause of warm months is to be sought in the pressure distribution in high latitudes, especially Alaska and the North Pacific. One can only say that in certain winters cyclonic storms enter the continent in high latitudes and that for reasons not yet known they are not closely followed by strong anticyclones.

In general, cold months in winter are due to an extraordinary flow of polar air equatorward or to the occurrence of one or more strong anticyclones that affect nearly the whole area between the Rocky Mountains and the Atlantic. The cold weather of the Pacific Coast States is rarely, if ever, felt on the Atlantic seaboard and vice versa and this may account in small measure for the rarity of negative temperature departures in winter over 100 per cent of the area of the United States. The only case of the kind in the last 20 years occurred in the month of May, 1917.

The question is sometimes asked: What is the probability that a month of pronounced abnormality will be followed by one of the same character? The answer is that the chances are about even that it will be followed by another month of the same character, although the magnitude of the depression of temperature may not be nearly so great as in the original month.

[1] By this expression is meant that part of the belt of high pressure that surrounds the globe about North latitude 35° which in winter is strongly developed over the continents and has two peaks of high pressure in the United States and in effect forms a ridge of high pressure between the Atlantic and Pacific.